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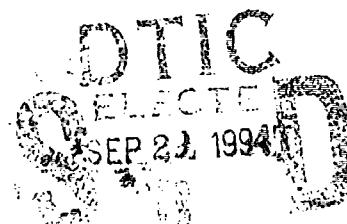


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FINAL REPORT  
JULY 1994

REPORT NO. 91-18

120MM MORTAR  
MIL-STD-1660 TESTS



94-30951

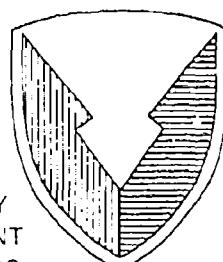
Prepared for:

U.S. Army Armament Research, Development  
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ATTN: SMCAR-AEP

Picatinny Arsenal, NJ 07806-5000

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<p>The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC), SMCAR-AEP, to conduct MIL-STD-1660 tests on 120MM mortar rounds on wooden pallets. This report contains test results of the 120MM mortar pallets which successfully passed MIL-STD-1660, Design Criteria for Ammunition Unit Loads, test requirements.</p>			
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22a. NAME OF RESPONSIBLE INDIVIDUAL <b>JEROME H. KROHN</b>		22b. TELEPHONE (Include Area Code) <b>815-273-8929</b>	
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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL  
VALIDATION ENGINEERING DIVISION  
SAVANNA, IL 61074-9639

REPORT NO. 91-18

120MM MORTAR MIL-STD-1660 TESTS

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## PART 1

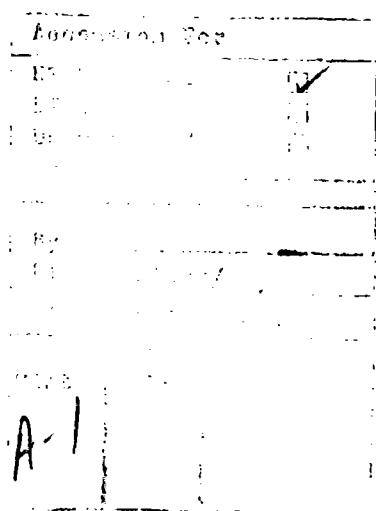
### INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC), SMCAR-AEP, to conduct MIL-STD-1660 tests of 120MM mortar rounds on wooden pallets.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of this series of tests was to determine if the 120MM mortar rounds on wooden pallets met MIL-STD-1660, Design Criteria for Ammunition Unit Loads, test requirements.

D. CONCLUSION. Two iterations of MIL-STD-1660 tests were conducted with 120MM mortar rounds unitized on wooden pallets with both tests meeting MIL-STD-1660 test requirements. The second iteration was conducted to improve the reliability of the fielded pallet with modifications to the dunnage and strap locations.



PART 2

APRIL 1992

ATTENDEES

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## PART 3

### TEST PROCEDURES

The test procedures outlined in this section were extracted from MIL-STD-1060, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The five tests that were conducted on the test pallets are summarized below.

A. STACKING TESTS. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of 1 hour. This stacking load is simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load is calculated in the following manner. The unit load weight is divided by the unit load height in inches and multiplied by 192. The resulting number is the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows. The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles-per-second. The frequency was steadily increased until the package left the platform. The resonant frequency is achieved when a 1/16-inch-thick feeler gage may momentarily slide freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieves  $1 \pm 0.1$  G. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurs, the total time of vibration is two hours if the specimen is tested in one position; and, three hours for more than one position.

C. EDGEWISE ROTATIONAL DROP TEST. This test shall be conducted by using the procedures of Method 5008, Federal Standard 101. The procedure for the Edgewise Rotational Drop Test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam is increased if necessary to ensure that there will be no support for the skids between the ends of the pallet when dropping takes place, but should not be high enough to cause the pallet to slide on the supports when the dropped end is raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation.

<u>GROSS WEIGHT NOT EXCEEDING</u> (Pounds)	<u>DIMENSIONS ON ANY EDGE NOT EXCEEDING</u> (Inches)	<u>HEIGHT OF DROP LEVEL A PROTECTION</u> (Inches)
600	72	36
3,000	no limit	24
no limit	no limit	12

D. INCLINE-IMPACT TEST. This test was conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the Incline-Impact Test is as follows: The specimen was placed on the carriage with the surface or edge which is to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber is attached to the bumper in the desired position before the test. No part of the timber is struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are

subjected to impacts are at the option of the testing activity and depends upon the objective of the tests. When the test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen is subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact was 7 feet-per-second.

PART 4

TEST EQUIPMENT

A. TEST PALLET.

1. Drawing.	19 48 4116/38A 20PA 1002
2. Width.	41-5/8 inches
3. Length.	50-1/8 inches
4. Height.	36-3/4 inches
5. Weight.	2,477 pounds

B. COMPRESSION TESTER.

1. Manufacturer.	Ormond Manufacturing
2. Platform.	60- by 60-inch
3. Compression Limit.	50,000 pounds
4. Tension Limit.	50,000 pounds

C. TRANSPORTATION SIMULATOR.

1. Manufacturer.	Gaynes Laboratory
2. Capacity.	6,000-pound pallet
3. Displacement.	1/2-inch amplitude
4. Speed.	50 to 400 rpm
5. Platform.	5- by 8-foot

D. INCLINED RAMP.

1. Manufacturer.	Conbur incline
2. Type.	Impact tester
3. Grade.	10 percent incline
4. Length.	12-foot incline

## PART 5

### TEST RESULTS

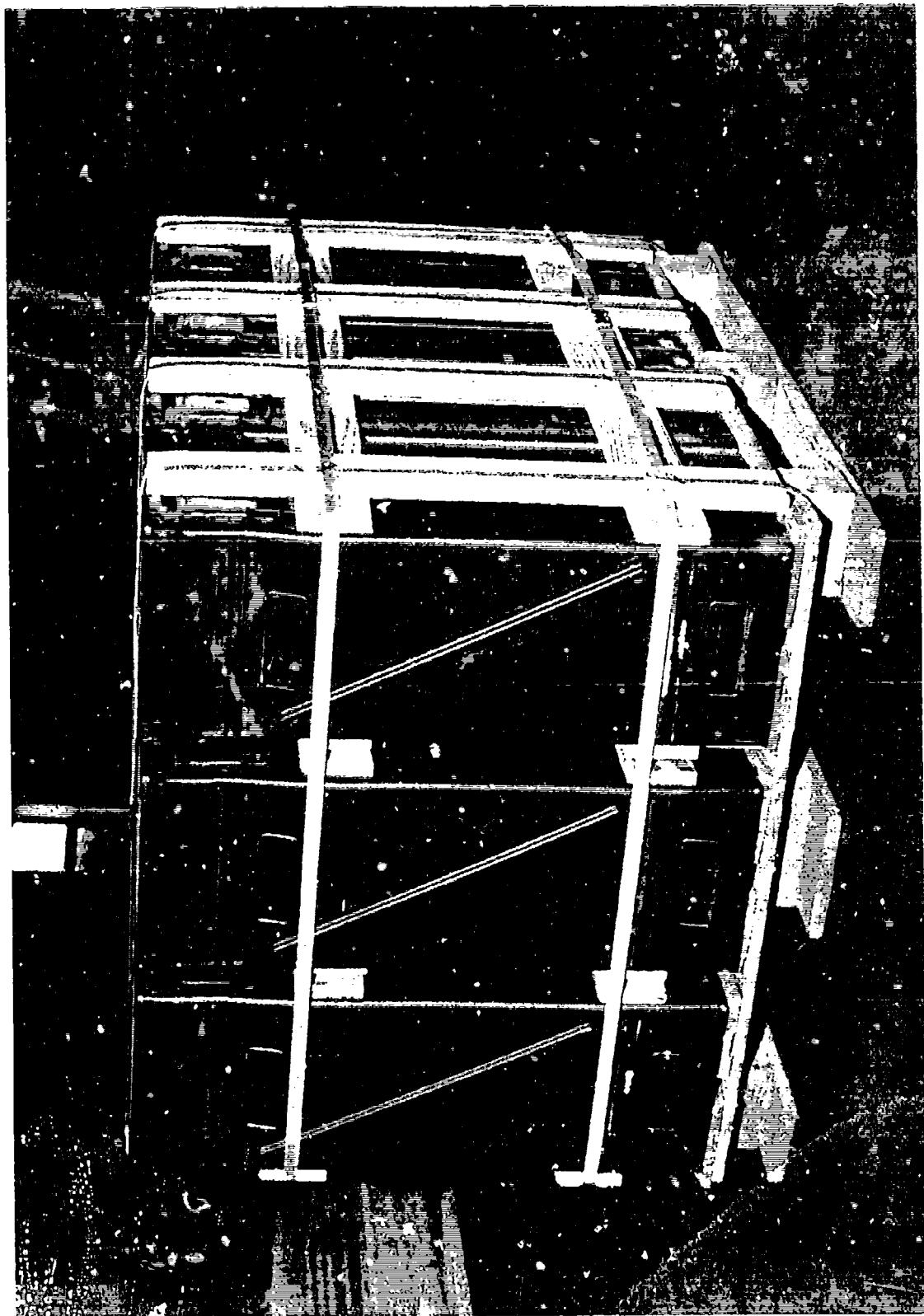
Two iterations of MIL-STD-1660 tests were conducted with different vertical and horizontal strap locations as well as changes in dunnage lengths. Although both designs passed MIL-STD-1660 requirements, the second test was conducted to improve on palletizing procedures for a tighter load. This design was deemed superior, affording greater pallet reliability in the field.

- A. STACKING TEST. During the first test the unit load was compressed to 25,000 pounds and relaxed after 1 hour with no problems encountered. During the second test the unit load was compressed to 24,000 pounds, again with no problems encountered.
- B. REPETITIVE SHOCK TEST. The first pallet was vibrated at 215 rpm. Shortly after starting this test, the center row of containers shifted outward approximately 2.5 inches. During the second 90 minutes of testing, the first pallet was vibrated at 210 rpm with the load remaining as stated above. The second pallet was vibrated at 205 rpm for the first 90 minutes and 195 rpm for the second 90 minutes, with no problems encountered.
- C. EDGEWISE ROTATIONAL DROP TEST. The first pallet was drop tested in a clockwise direction until all four sides were tested. At the end of this test, one stringer board had failed with the center row of containers sticking outward 2.5 inches. The intermediate dunnage had also shifted approximately 1.25 inches. The vertical bands on this pallet had also shifted between the containers which could result in loose strapping. The second pallet successfully completed all four drops.

D. INCLINED-IMPACT TEST. The incline plane was set to allow the pallets to travel 8 feet prior to impacting a stationary wall. The pallets were rotated clockwise after each impact, until all four sides had been tested. After testing, the first pallet still had the intermediate dunnage shifted outward 1.25 inches, as stated above, with one vertical band close to becoming disengaged. The second pallet experienced no problems during this test.

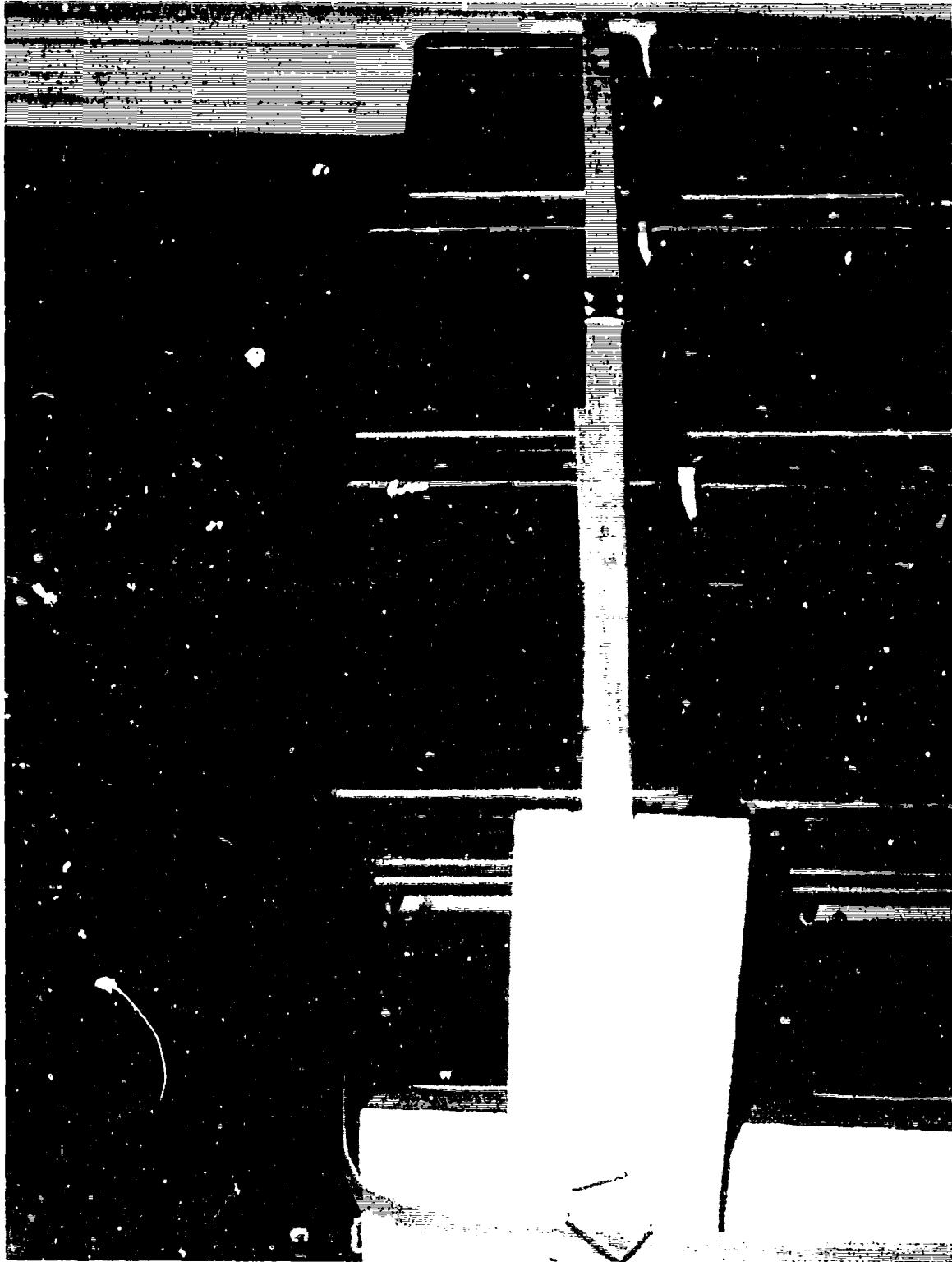
PART 6

PHOTOGRAPHS



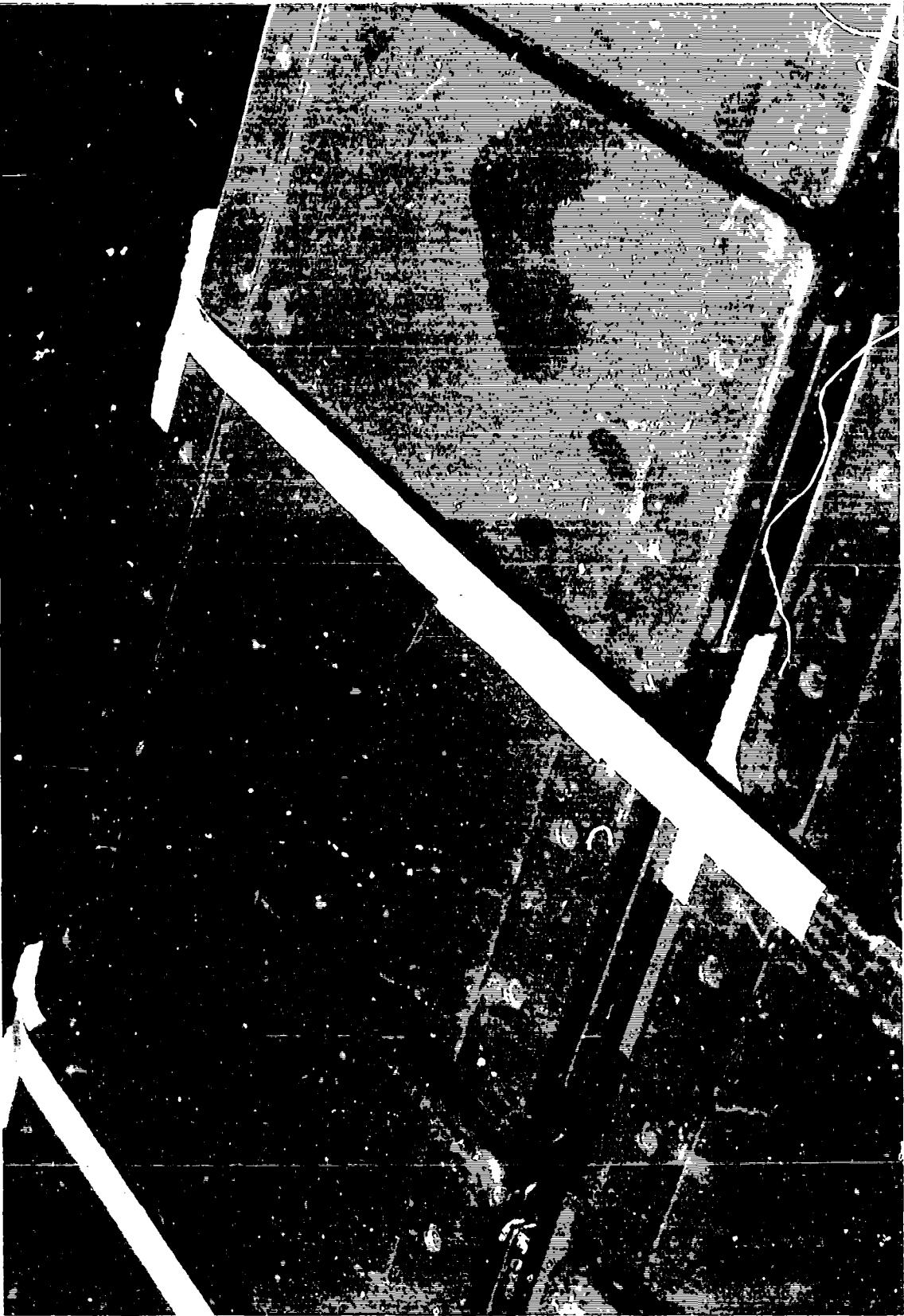
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

PHOTO NO. AO317-SCN92-303-3595: This photo shows an overall view of the configuration of the pallet prior to testing.



U.S. ARMY DEFENSE AMMUNITION CENTER AND  
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PHOTO NO. A0317-SCN92-303-3597: This photo shows the top of the pallet after testing. Note, racking of the 120MM mortar containers after testing.



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL

PHOTO NO. AO317-SCN92-303-3596: This photo shows the first iteration of tests prior to changes in pallet unitization procedures. Note the strap alignment between containers which could result in loose banding. Changes in the unitization procedures align the strapping in the center of the containers.

PART 7

APPENDIX

## APPENDIX 38A

# UNITIZATION PROCEDURES FOR BOXED AMMUNITION AND COMPONENTS ON 4-WAY ENTRY PALLETS

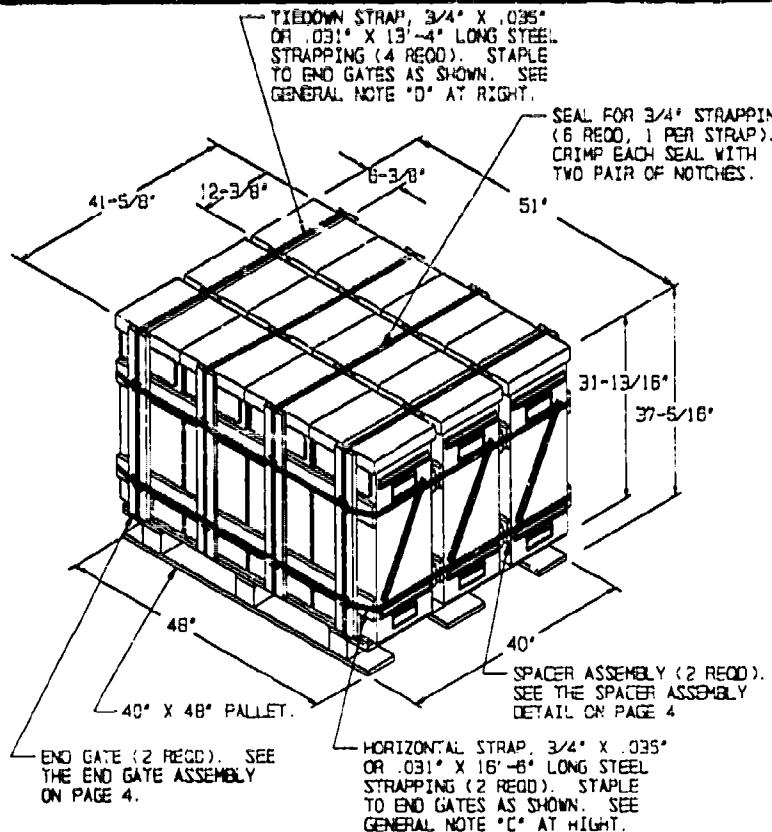
CARTRIDGE, 120MM MORTAR, PACKED 2 PER PA154 METAL CONTAINER, UNITIZED 24 CONTAINERS PER 40" X 48" PALLET; APPROX BOX SIZE 12-3/8" L X 6-3/8" W X 31-13/16" H

NOTICE: THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4116-20PA1002.

U.S. ARMY MATERIEL COMMAND DRAWING					
APPROVED, U.S. ARMY ARMAMENT, MUNITIONS AND CHEMICAL COMMAND <i>M.J.K.</i> David A. Pashore, <i>Sgt. 1st Cl. PFC</i> SMCAR-E&K		DRAFTSMAN ENGINEER	BETTY J. KUNDERT SANDRA M. SCHULTZ		
SUPPLY ENGINEERING DIVISION ANSMC-TM&T		TRANSPORTATION ENGINEERING DIVISION	VALIDATION ENGINEERING DIVISION		
APPROVED BY ORDER OF COMMANDING GENERAL, U.S. ARMY MATERIEL COMMAND <i>W. Ernst</i> William G. Ernst		LOGISTICS ENGINEERING OFFICE <i>William G. Ernst</i>			
U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL <i>W. Ernst</i> William G. Ernst		JULY 1994			
		CLASS 19	DIVISION 48	DRAWING 4116/ 38A	FILE 20PA 1002
DO NOT SCALE					

PALLET UNIT DATA				
ITEMS INCLUDED		HAZARD CLASS AND DIVISION		APPROX WEIGHT LBS
NSN	DDODIC	OD CLASS	COMP GROUP	
1315-01-335-5016	C379	1.1	E	2,477
01-343-1941	C623	1.1	E	2,477
01-343-1940	C624	1.2	H	2,477
01-343-1942	C625	1.2	G	2,477

HAZARD CLASSIFICATION DATA CONTAINED IN THE ABOVE CHART IS FOR GUIDANCE AND INFORMATIONAL PURPOSES ONLY. VERIFICATION OF THE SPECIFIED DATA SHOULD BE MADE BY CONSULTING THE MOST RECENT JOINT HAZARD CLASSIFICATION SYSTEM LISTING OR OTHER APPROVED LISTINGS).



### PALLET UNIT

SEE GENERAL NOTE "B" AT RIGHT

24 BOXES OF 120MM MORTAR CTG (2 PER BOX)	97 LBS	2,328 LBS (APPROX)
DUNNAGE	-	70 LB4S
PALLET	-	80 LBS

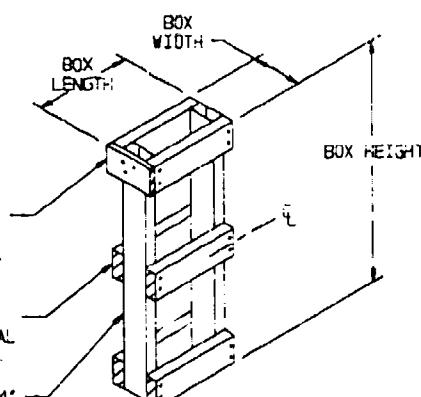
TOTAL WEIGHT - - - - - 2,478 LBS (APPROX)  
CUBE - - - - - 47.90 CU FT (APPROX)

BILL OF MATERIAL		
LUMBER	LINEAR FEET	BOARD FEET
1" X 4"	93.33	31.11
NAILS	NO. REQD	POUNDS
5d (2")	56	.33
10d (3")	48	.74
PALLET, 40" X 48"	1 RECD	80 LBS
STEEL STRAPPING, 3/4"	85.21' RECD	5.16 LBS
SEAL FOR 3/4" STRAPPING	6 RECD	NIL
STAPLE, 15/16" X 3/4"	24 RECD	NIL

FILL PIECE, 1" X 4" X BOX  
WIDTH (1 RECD). NAIL TO A  
VERTICAL PIECE W/3-6d NAILS.

HORIZONTAL PIECE, 2" X 4" X BOX  
LENGTH (6 RECD). NAIL TO VERTICAL  
PIECES W/2-10d NAILS AT EACH END.

VERTICAL PIECE, 2" X 4"  
X BOX HEIGHT (2 RECD).



**FILLER ASSEMBLY**  
(FOR MINUS ONE BOX)

- A. THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19 48 4116 20PA1002. TO PRODUCE AN APPROVED UNIT LOAD, ALL PERTINENT PROCEDURES, SPECIFICATIONS AND CRITERIA SET FORTH WITHIN THE BASIC DRAWING WILL APPLY TO THE PROCEDURES DELINEATED IN THIS APPENDIX. ANY EXCEPTIONS TO THE BASIC PROCEDURES ARE SPECIFIED IN THIS APPENDIX.
  - B. DIMENSIONS, CUBE AND WEIGHT OF A PALLET UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE BOXES AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.
  - C. INSTALL EACH HORIZONTAL STRAP TO BE LOCATED AS SHOWN. HORIZONTAL STRAPS MUST BE TENSIONED AND SEALED AFTER THE APPLICATION OF TIEDOWN STRAPS.
  - D. INSTALL EACH TIEDOWN STRAP TO PASS UNDER THE DECK/STRINGER BOARDS OF THE PALLET AND TO BE LOCATED AS SHOWN.
  - E. THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS APPENDIX.
- CARGOLOADING - - - - - 19-48-4115-1SPA1002  
TRUCKLOADING - - - - - 19-48-4117-11PA1003  
STORAGE - - - - - 19-48-4119-1-2-3-4-14-22PA1002  
COMMERCIAL  
CONTAINER - - - - - 19-48-4153-1SPA1002  
MILVAN - - - - - 19-48-4166-1SPA1003  
SIDE OPENING COMMERCIAL  
CONTAINER - - - - - 19-48-5257-1SPA1009
- F. FOR METHOD OF SECURING A STRAP CUTTER TO THE PALLET UNIT, SEE AMC DRAWING 19 49 4127 20P1000.
  - G. IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS APPENDIX, THE BOXES NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS APPENDIX.
  - H. THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING 120MM MORTAR CARTRIDGES WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN WHAT IS SHOWN ON PAGE 2, PROVIDED THE CONTAINER DOES NOT VARY FROM WHAT IS DELINEATED HEREIN. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.
  - J. THE STYLE I PALLET DELINEATED IN THE DETAIL AT LEFT NEED NOT HAVE CHAMFERS OR STRAP SLOTS AS SPECIFIED WITHIN MILITARY SPECIFICATION MIL-P-15011 WHEN USED FOR THE UNITIZATION OF ITEMS COVERED BY THIS APPENDIX.
  - K. CONTAINERS MUST ALL BE ORIENTED IN THE SAME DIRECTION ON THE PALLET SO THE INTERLOCKING DEVICES WILL ENGAGE.
  - L. ALL DUNNAGE SHALL BE PRESERVATIVE TREATED IN ACCORDANCE WITH GENERAL NOTE "X" IN THE BASIC PROCEDURES.

### GENERAL NOTES

SEE GENERAL NOTE "B" AT RIGHT

24 BOXES OF 120MM MORTAR CTG (2 PER BOX)	97 LBS	2,328 LBS (APPROX)
DUNNAGE	-	70 LB4S
PALLET	-	80 LBS

TOTAL WEIGHT - - - - - 2,478 LBS (APPROX)  
CUBE - - - - - 47.90 CU FT (APPROX)

BILL OF MATERIAL		
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PALLET, 40" X 48"	1 RECD	80 LBS
STEEL STRAPPING, 3/4"	85.21' RECD	5.16 LBS
SEAL FOR 3/4" STRAPPING	6 RECD	NIL
STAPLE, 15/16" X 3/4"	24 RECD	NIL

FILL PIECE, 1" X 4" X BOX  
WIDTH (1 RECD). NAIL TO A  
VERTICAL PIECE W/3-6d NAILS.

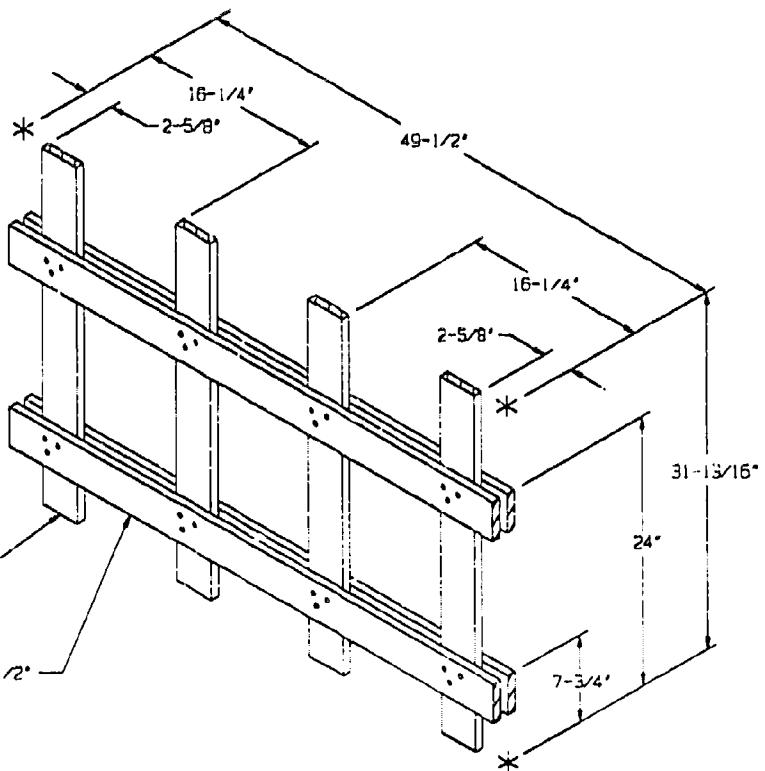
HORIZONTAL PIECE, 2" X 4" X BOX  
LENGTH (6 RECD). NAIL TO VERTICAL  
PIECES W/2-10d NAILS AT EACH END.

VERTICAL PIECE, 2" X 4"  
X BOX HEIGHT (2 RECD).

**FILLER ASSEMBLY**  
(FOR MINUS ONE BOX)

VERTICAL PIECE, 1" X 4" X  
31-1/4" (4 RECD).

HORIZONTAL PIECE, 1" X 4" X 49-1/2"  
(1 RECD). NAIL TO THE VERTICAL  
PIECES  $\frac{1}{3}$ -10d NAILS AT EACH  
JOINT AND CLINCH.



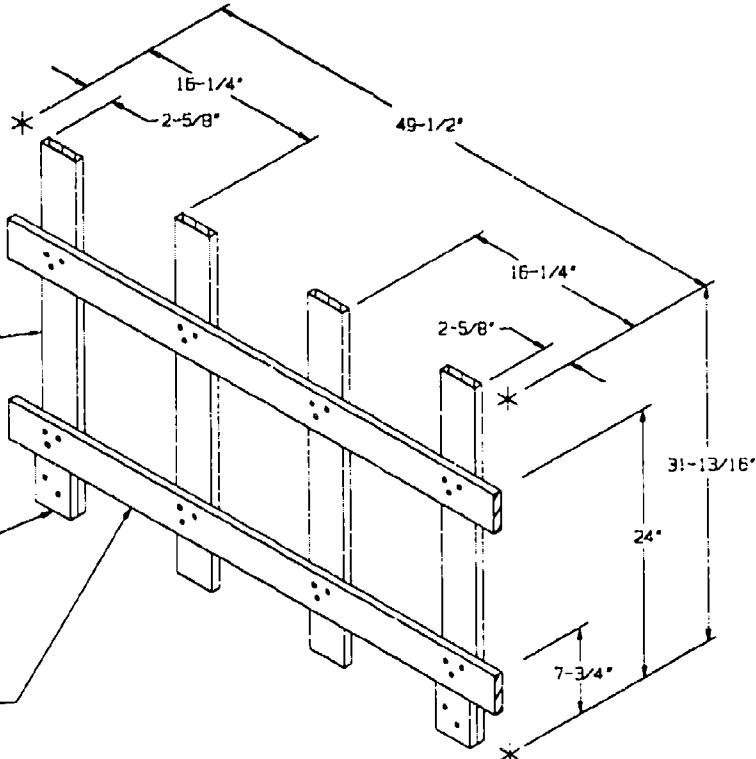
#### SPACER ASSEMBLY

(2 RECD)

VERTICAL PIECE, 1" X 4" X  
31-1/4" (4 RECD).

SUPPORT PIECE, 1" X 4" X 4-1/4"  
(2 RECD). NAIL TO VERTICAL  
PIECE  $\frac{1}{2}$ -6d NAILS AND CLINCH.

HORIZONTAL PIECE, 1" X 4" X 49-1/2"  
(2 RECD). NAIL TO THE VERTICAL  
PIECES  $\frac{1}{3}$ -6d NAILS AT EACH  
JOINT AND CLINCH.



#### END GATE

(2 RECD)